

A Work Project, presented as part of the requirements for the Award of a Master Degree in Economics from the NOVA – School of Business and Economics.

How to monitor the front end of innovation in the new product
development: defining performance indicators.
The case study of an accelerator of technology commercialization

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Abstract

The present paper has the ambition to define performance indicators that monitor the performance all along the front end process in the new product development. In order to answer the following research question:” What are the relevant performance indicators when monitoring the front end of innovation?” the dissertation starts with a literature review followed by observations based on a case study of the accelerator of technology commercialization “Cohitec”. The results revealed the importance to subdivide the front end into distinct periods in order to find the appropriate indicators for each moment in the process. Three periods were identified namely exploration, validation and business case. In addition to the performance indicators identified in the literature, the case study enabled to extent the panel of indicators by adding criteria related to the technology, the value proposition, the plan of development and the market targeted.

Key-words: Front end of innovation, performance indicators, monitoring, criteria

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Introduction

Nowadays, innovation and especially the new product development offer great opportunities to create and to strengthen competitive advantages (Reguia, 2014).

Many known authors (Cooper 1988; Cooper & Kleinschmidt, 1991, 1994; Frishammar & Florén, 2008; Herstatt & Verworn, 2001; Langerak et al., 2004,) have raised awareness about the importance of the earliest stages in the innovation process –named **the “front end of innovation”** and based on their studies, have proved the strong influence that it has on the innovation and the product successes. However, a very few researches were carried out in the study of performance control in the front end of innovation.

The present paper gives an opportunity to monitor the front end of innovation by proposing a set of performance indicators. The problematic of this thesis is formulated as the following: “How to monitor the front end of innovation in the new product development: defining performance indicators. *The case study of an accelerator of technology commercialization*”.

In order to answer the question, a literature review dealing with the concepts of new product development, front end of innovation and performance indicators is presented. Stemming from the academic literature, several performance indicators are considered for the research.

The following task is to identify the relevant indicators required in a practical situation with the case study of “Cohitec”.

THEORETICAL PART: LITERATURE REVIEW

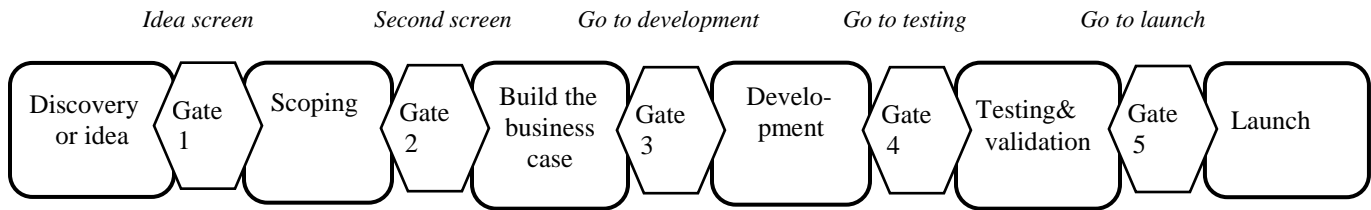
1. New product development process

The scope of the research covers the innovation process aiming at launching new products¹ on the market; in the literature, it is referenced as the “New Product Development process “(NPD). The NPD process includes the complete process and the activities by which a new- improved- product or service is brought on the market (Cooper, 1988). The process is usually split into several theoretical phases, presenting a standard framework which has the aim of lessening risk (Booz, Allen & Hamilton, 1982).

A very well-known model of new product development process is the Stage-gate model (SG model) developed by Cooper (1988). It is a conceptual roadmap that breaks the product innovation into a predetermined sequential set of stages separated by management decisions gates. Throughout the process, teams are expected to collect information aiming at reducing the project uncertainty and risk until facing a management gate in which the project is being evaluated against quality criteria (Cooper, 2008).

¹ Throughout this thesis, when using the term product, we refer to products and services.

Figure 1: The Stage-Gate model by Cooper (1988)



The objective of the paper is to propose a set of performance indicators which works similarly as the quality criteria used for each management gate in the SG model.

2. The front end of innovation

The NPD process has been introduced, however the focus is on the upstream part of the NPD process, named the **“front-end” of innovation** by Koen et al. (2001).

2.1 Definitions

According to Koen et al. (2001, 2002), the front end of innovation stands as the earliest stage of the NPD process and refers to the unpredictable and unstructured activities taking place before the development stage. Kim & Wilemon (2002b) and Moenaert et al. (1995) provide a definition of the FEI related to a period of time: the front end begins when an opportunity is identified and estimated to be worth enough to be explored, and it ends when the management takes the decision to terminate the project or to commit to larger investments in the development stage.

Eric Stevens (2014) resumes the causes of the fuzziness in the early front-end in three elements: uncertainty, equivocality and complexity. The uncertainty comes from a lack of information regarding the customer, the technology and the market competition (Doll & Zhang, 2001).

Equivocality is the situation where multiple meanings can be made from the same facts or data. As a consequence, multiple decisions may be taken according to the diverse interpretations (Stevens,

2014). Finally, the complexity is initiated in information processing where a decision of one facet of the project influences the other aspects.

2.1 Importance and characteristics

For a long time, the front end has been an area of too little attention and a great weakness in product innovation (Khurana & Rosenthal, 1998) although it represents one of the most important opportunities to improve the global innovation process (Koen et al., 2001). The front end of innovation is a key step in the development of new products whose purpose is to provide a well-defined product concept before the development stage (Kim & Wilemon, 2002b) which is source of product success (Cooper & Kleinschmidt, 1991). Dr. Cooper (1988, 1990) states that the front end stage is of paramount importance since decisions made during the FEI can condition the following stages of the NPD process and more specifically, the development phase in which large investments are being made.

2.2 Models of the front end of innovation

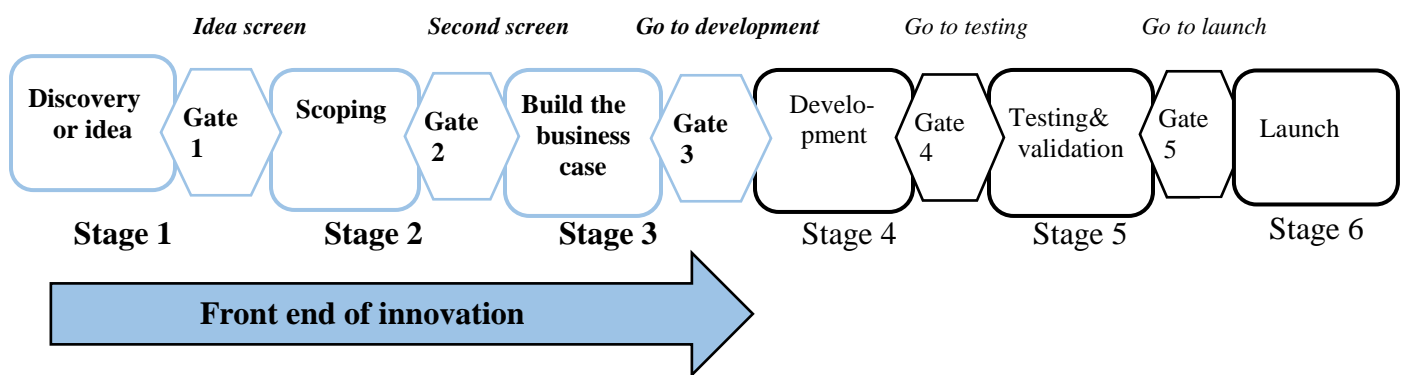
The activities of the front end of innovation are informal and unpredictable by nature (Gassman & Schweitzer, 2014). Nevertheless, three main approaches modelling the front end of innovation can be identified in the literature explicitly linear, dynamic and entrepreneurial.

2.2.1 Linear approach

Sequential NPD models adopt a linear conduct of the front end (Gassman & Schweitzer, 2014). A sequential model means that in order to move to the next step and progress in the process, the project must succeed the previous stages. Even though iteration may occur, it is mostly a step-by-step model (Du Preez & Louw, 2008).

As an example, the front end of innovation presented in the 1988' Stage-gate model follows a linear course as it integrates a pre-determined sequence of front end activities (Cooper, 1988). In this linear model, the front end of innovation corresponds to the first three stages - idea or discovery, scoping and build the Business Case and the first three gates – Idea screen, second screen and go to development.

Figure 2: The front end in the Stage-gate model

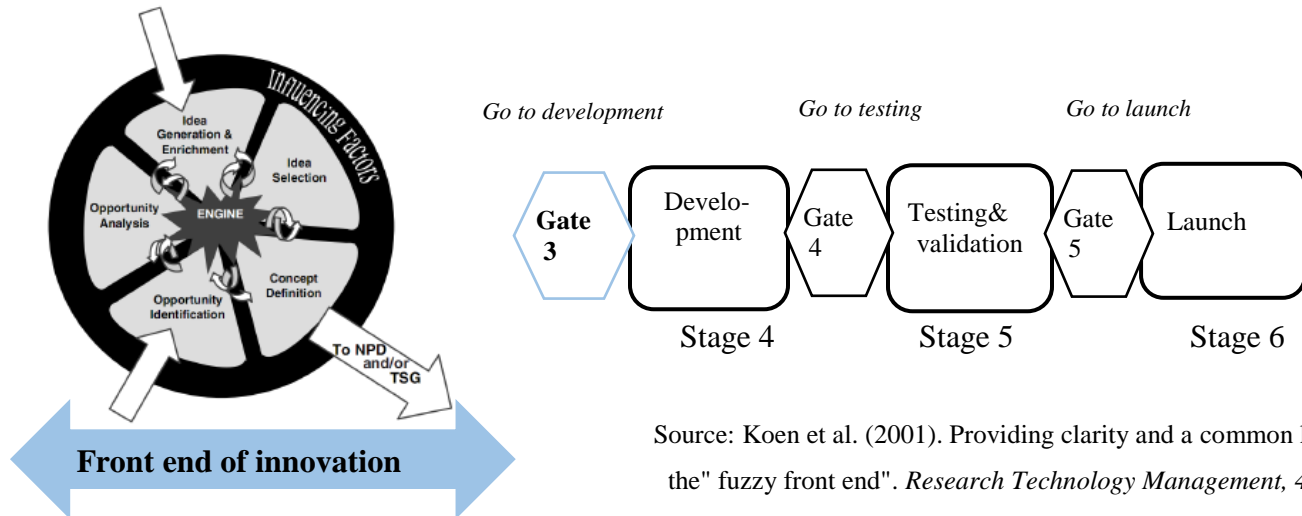


2.2.2 Dynamic approach

Linear models of front end of innovation are subject of much criticism: some NPD theorists (Cooper, 2014a; Gassman & Schweitzer, 2014) claim that they are running the risk of not corresponding to the market reality and do not sufficiently provide creative exchange and feedback loops. Therefore, new forms of front end more dynamic were introduced.

As an example of dynamic approach, the “New Concept Development model” (NCD) of front end designed by Koen et al. (2001) is described. The NCD model is a circular model in which actions are performed in a non-sequential way: ideas can flow in any combination of activities, they are allowed to iterate and to use the front end activities more than once. There is no specific order among the five elements (Koen et al., 2001).

Figure 3: The NCD model of front end of innovation by Koen et al. (2001)

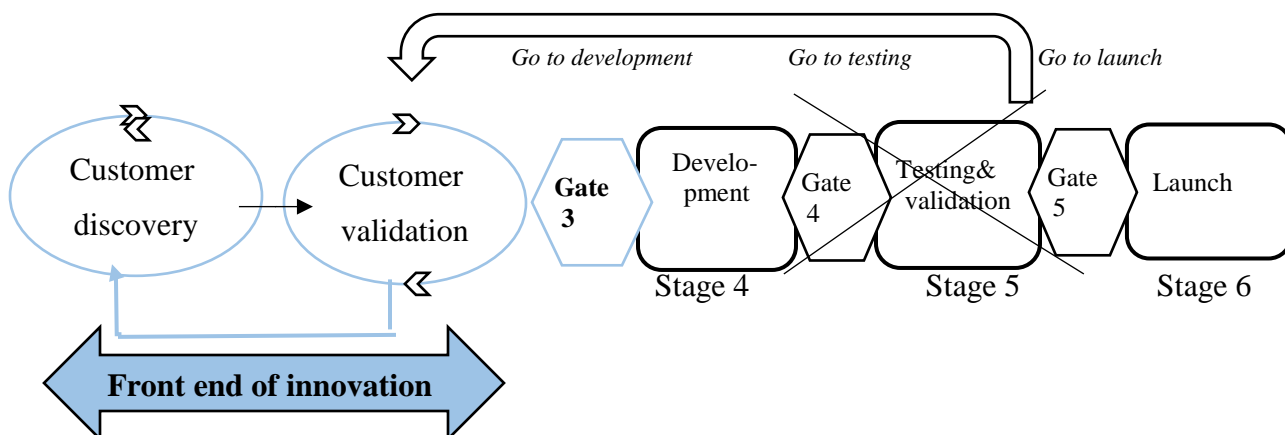


2.2.3 Entrepreneurial approach

Recently, a new approach of NPD process has emerged within the startup environment: the Customer Development process (CD process) developed by Blank (2006). Instead of taking part in planning and research activities for a certain period of time- what traditional NPD approach requires- entrepreneurs list a series of hypotheses that they will test “outside of the building” through the customer development process (Danes & York, 2014).

With the integration of the Customer Development process within the Stage-gate model, the front end of innovation is then illustrated by the two first steps i.e. Customer Discovery and Customer Validation. The figure 4 illustrates the adaptation of the CD process within the SG model.

Figure 4: The customer development process (Blank, 2006)



Entrepreneurs test whether the hypothesis regarding the problem, the customer and the product of the business plan are correct. Only when customers validate the hypotheses, the company can move to the execution phase and create a full business case (Blank, 2006). Completing these two stages permits to confirm the company business model (Maurya, 2012).

To resume, authors agree to state that the front end of innovation is everything that comes before to formal go/no go decision to move the project forward in the development stage of the innovation process (Kim & Wilemon, 2002b; Koen et al., 2001, 2002; Moenaert et al., 1995; Vilarinho, 2015). The final outcome of the front end is a business case which contains the financial and business analysis of the project and gathers the product definition, the project justification and an action plan for further steps (Khurana & Rosenthal, 1997).

3. Performance indicators

This section raises the issue regarding the indicators allowing to assess the performance all along the front end process.

3.1 Objectives

Measuring the front-end performance is particularly challenging due to its uncertain and non-routine nature (Frishammar & Florén, 2008). As a consequence, financial measures of NPD performances such as profits, market shares or sales do not often apply and there is no universal common measures of FEI performance (Kleinschmidt, Koen & Reilly, 2005). Therefore, subjective criteria through perception-based criteria are usually applied (Poskela and Martinsuo, 2009).

Doll & Zhang (2001) state that the principal goal of the performance indicators is to give an opportunity to monitor and measure the performance of the project in the front end of innovation. Especially, it allows to monitor the progress along critical dimensions such as cost, time,

profitability etc. (Chiesa, Frattini, Lazzarotti & Manzini, 2009). It gives the opportunity to point out the weaknesses and to improve the front end practice (Poskela, 2009). Also, a system of performance measurement in the front end gives information about the efficiency of the process and the effectiveness of its outcomes (Berg et al., 2009) which can be used to provide support in the decision-making process by offering to the decision-makers sufficient knowledge about alternative ideas and consequently by promoting the current choices (Poskela & Martinsuo, 2011). The information collected also contributes in reducing technical and commercial uncertainty and the risk of the project (Chiesa et al., 2009).

Koen et al. (2002) add that performance appraisal is a means to stimulate the generation and enrichment of ideas. In addition, it provides incentives and motivation to the teams to meet the objectives (Chiesa et al., 2009).

3.2 Classification of indicators

Berg et al. (2006) state that the front end process and its outcomes should be measured. Kim & Wilemon (2002a) agree that the front end project should be assessed by the means of evaluating its outcomes, also they contend that the team is of major significance and should be gauged. For this purpose, the following literature review is related to the evaluation of the individual project that includes its outcomes and the team dynamics-related indicators.

3.2.1 Efficiency and effectiveness

Efficiency and effectiveness are common performance measures of the FEI in the literature. In their work, Ho & Tsai (2011) construct two indicators for each measure of efficiency and effectiveness. They evaluate the efficiency of the process with the indicators: (i) The project was one of the fastest undertaken in the company and (ii) in the FEI, actual development costs overtook the budget dedicated to the development. Regarding the effectiveness, they present the following indicators:

(i) The project plan is explicit and stable and (ii) The product concept is clear and in line with customer needs.

3.2.2 Future business potential

In 2009, Poskela & Martinsuo publish an article aiming at measuring the front-end performance by defining the future business potential coming from the product generated in the FEI. The future business potential is the ability of the FEI to define a product which has the potential to create opportunity windows for new market entries and NPD activities (Poskela & Martinsuo, 2009). For this, the authors propose four indicators that enable to evaluate whether the product has future business potential: (i) The product gives access to new markets, (ii) The product opens up new NPD possibilities, (iii) The product creates new market know-how, (iv) The product creates new technical know-how.

3.2.3 Team composition and team dynamics

Previous works presented the importance of a quality team in the creation of a superior concept at the end of the front end (Frishammar & Florén, 2008; Herstatt et al., 2008; Langerak et al., 2004; Moenaert et al., 1995, Reid, Hultink & Barczak., 2013). As a quality team helps reducing the uncertainties in the front end of innovation (Herstatt, Nagahira and Verworn, 2003), the authors suggest it to be a suitable measure of performance. Based on former studies (Ho & Tsai, 2011; Hoegl & Gemuenden, 2001; Moenaert et al., 1995; Doll & Zhang, 2001), the indicators related to the team composition and team dynamics include five measures: (i) The team is composed of cross-functional experts, (ii) The team has sufficient knowledge and capabilities to perform specialized roles, (iii) The project quickly develops team vision, shared purpose and creates a team spirit, (iv)

The team communicates and coordinates well, (v) All team members are able to bring in their expertise to their full potential.

3.2.4 Competitive advantage

The competitive advantage expresses itself in terms of product superiority compared to competing products on the market (Poskela, 2009). Poskela & Martinsuo (2009) decompose the competitive advantage in four indicators: (i) The product offers uniqueness to consumers, unique features compared to competing products, (ii) The product solves important customer problems, (iii) The product has superior price/performance ratio compared to competitors, (iv) The product reaches high customer satisfaction.

3.2.5 Strategic fit

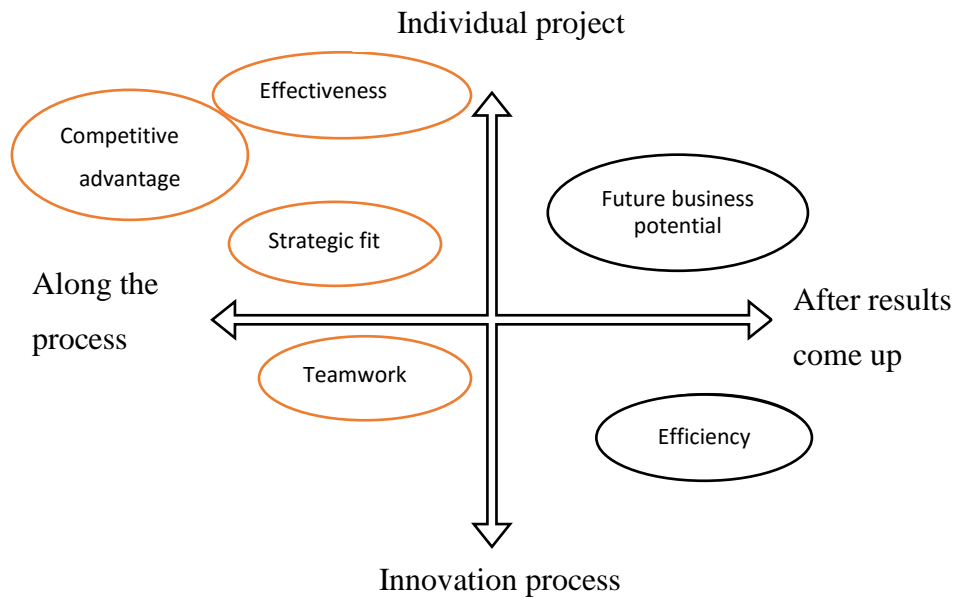
The strategic fit is an appropriate measure of performance since it has the ability to predict the future financial performance of the project and hence its success (Cooper & Kleinschmidt, 1987² cited in Aura, 2007). Aura (2007) decomposes the strategic fit criteria into three indicators of performance: (i) The project fits with the portfolio of products of the company, (ii) The project fits with the business strategy, (iii) The projects fits with the existing resources.

3.3 Selection of performance indicators

In order to deliver a set of quality criteria able to monitor the performance all along the front end process, indicators verifiable only after results come up are excluded from the scope of the study. This includes the indicators based on future estimations and the “reliability” indicators that compare expectations with results.

² Cooper, R.G., Kleinschmidt, E. J. (1987) New products: What separates winners from losers. *Journal of Product Innovation management*, 4(3):169-184

Figure 5: Selection of indicators



Following this reasoning, the efficiency and the future business potential are both excluded.

The indicators presented in this research do not constitute an exhaustive set of performance measures; the paper is based on specific previous authors' works i.e. Aura (2007); Doll & Zhang (2001); Herstatt et al. (2008), Ho & Tsai (2011); Hoegl & Gemuenden (2001); Poskela & Martinsuo (2009, 2011); and the scope is restricted to the indicators measuring the performance all along the process. Also, the performance indicators studied in the literature review are related to the innovation project including its outcomes. Indicators related to the process include only the indicators about the team performance. Hence, the criteria about the process itself are not entirely covered by the scope of the thesis.

4. Case study: Cohitec



Cohitec is a training program in technology commercialization, part of the Accelerator of Commercialization Technology (ACT) initiative developed by Cotec Portugal. It presents itself as an accelerator which is defined in the literature as a sort of business incubation program that supports the entrepreneurial teams and their (future) ventures to connect with investors and additional important stakeholders as well as to have access to their resources (Malek, Maine and McCarthy, 2014). Cohitec purpose is to support the knowledge produced in Portuguese R&D institutions. The program lasts four months and presents two main objectives: assess the commercial viability of the products or services that can be developed from the technologies proposed by the participants and induce entrepreneurial and technology commercialization skills in the participants.

5. Methodology

The purpose of this thesis is to give an opportunity to monitor the front end of innovation by defining relevant performance indicators with the aim of helping teams to succeed in the process. For this end, the research questions we tend to give an answer to is:” What are the relevant performance indicators when monitoring the front end of innovation?”.

5.1 Research methods and strategy

For the purpose of the present thesis, the qualitative method is selected. The qualitative approach includes data collection techniques such as interviews or questionnaires that generate and use non-numerical data (Saunders et al., 2012). It was preferred over the quantitative approach since

collecting Cohitec participants and coordinators' feelings, opinions and experiences were necessary in the definition of relevant indicators of performance.

In the business research methods, two natures of relationship between theory and research exist depending on whether data are collected in order to test or to build theories namely deductive and inductive approaches (Bryman & Bell, 2007). For this research, deductive reasoning was selected as the process starts with an established theory or generalization and seeks to see whether the theory applies to specific instances (Hyde, 2000: 90).

The study of a specific case was favored over multiple case studies. According to Yin (2003), the case study is preferred when the investigator has few control on the events and when the focus is on a contemporary phenomenon in a real-life context.

5.2 Data collection and analysis

There exist multiple options to collect primary data. Triangulation of data is the combination of methodologies in the study of the same phenomenon (Denzin, 1970) and is usually preferred as it achieves more reliable and robust results. With the aim of following the triangulation strategy and integrate different perspectives in the collection of data, three research methods were undertaken: unstructured and semi-structured interviews, participant observation and document analysis.

Unstructured interviews were carried out in the very beginning of the study with the objective to have a better overview of the situation at Cohitec and the problematic itself. Thereafter, semi-directed interviews were conducted as it is directed in the form of a general discussion and allows the interviewer to adapt the questions according to the answers given by the interviewee (Bryman and Bell, 2007). The interviewees were the coordinator of Cohitec Lisbon and the coordinator of Cohitec Porto, the President of Cohitec as well as two participants to the training program.

In addition, participant observation method was used. It allows the researcher a total immersion in the research setting (Saunders et al., 2012) and obtain direct experience of a specific situation. Finally, document analysis is the third type of qualitative research method carried out. With the collaboration of the Cohitec Staff, I had access to different documents able to nourish the practical part.

Regarding the analysis method for the semi-directed interviews, it was separated in three steps: recording and transcribing, data reduction and finally connection with literature review. All the interviews were recorded and transcribed on paper for the data to be examined. Then data reduction was performed by summarizing the different main aspects treated during each interview as primary qualitative data. The final step was consisting of connecting the primary data and practical discoveries with the literature review in order to prepare the result discussions and subsequently, make a general conclusion and write recommendations. Documents issued from Cohitec and personal notes were subject to a similar method of analysis. First, a data reduction with the objective to resume the main facets was undertaken prior to linking qualitative primary data with the theoretical part.

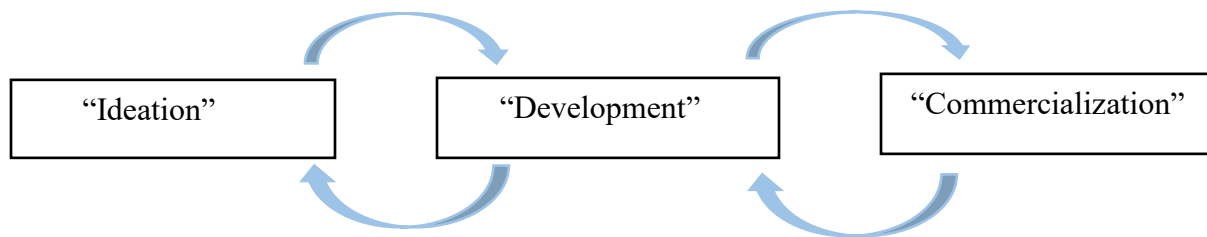
6. Observations

6.1 The front end of innovation at Cohitec

The front end of Cohitec is designed in three sequential stages that the institution names “ideation”, “development” and “commercialization” and is illustrated in figure 6. It follows the technology entrepreneurship commercialization methodology³.

³ Find more information: Vilarinho, P. M. (2015). COTEC’s Technology Commercialization Accelerator (Act®). *Competitive Strategies for Academic Entrepreneurship: Commercialization of Research-Based Products: Commercialization of Research-Based Products*, 188.

Figure 6: The front end of innovation at Cohitec



According to the Cohitec 'structure, the objective in the “ideation” phase is to generate multiple product concepts and thus multiple value propositions based on the technology developed by the participant(s). At the end of the phase, must be delivered a set of clearly defined product concepts. The goals of the “development” phase are to refine and improve the product concepts generated in the “ideation” phase and to select among them, the ones worth for further evaluation. The “development” phase challenges and sustains each of the product-market linkages produced in the “ideation” phase. The selection and validation of product concepts is supported by a set of analytical and management tools (e.g., 5 forces of Porter, SWOT analysis, industry mapping, voice of the customer, etc.) from which participants get a better understanding of the market reality (Vilanriho, 2015).

The “commercialization” stage has the purpose to end up with a business proposal which is the final outcome of the program. Typically, it builds the development strategy of the chosen product concept. The business proposal (or business case) reunites all the previous outputs and gathers the information collected so far throughout the program.

6.2 Indicators of performance

According to Cristina Simões, coordinator of Cohitec Lisbon, the set of performance indicators has the objective to help teams, “at least psychologically and emotionally”, by providing proper feedbacks on their performance.

According to two coordinators and the President of Cohitec, the best way to define relevant performance indicators is to separate the front end process in multiple stages given the nature of each stage. The advantage of setting quality criteria that follows the sequence of activities is that it does not create additional noise for the teams.

6.2.1 Ideation

The starting point of the process is to connect the technology with the product ideas. Therefore, before even starting generating ideas, one should ensure the business potential of the technology and assess whether the technology meets specific performance criteria.

Based on the interviews, the technology must meet the following three criteria: (i) The technology is protectable, (ii) The technology is scalable and (iii) The technology is unique.

In the ideation phase, the most important outcome delivered is the value proposition (VP) related to the product concept which is a statement made by company that explains why customers should buy the products or services and convinces of the uniqueness of the offer compared to competitors (Skok, 2013). In order to be effective, the VP must: (i) identify market problems, (ii) solve market needs and (iii) have a clear product concept.

The product idea must also follow a performance assessment and in order to obtain a significant potential it must (i) Have a superior performance/price ratio compared to competitors, (ii) Have unique features, (iii) Be able to satisfy customers and (iv) Have a different proposition from competitors.

Finally, the Director of ACT believes “it is better to have an outstanding team with a not so good project than the opposite because if the team does not work out, indeed good results cannot be produced”. Following this, the coordinators of Cohitec claim that teams should meet specific criteria: (i) Cross-functional experts in the team, (ii) Sufficient capabilities and knowledge within

the team to develop the project, (iii) Communication and coordination within the team, (iv) Integration of team members for them to provide their best expertise.

The interviewees state that team criteria are not specific to the idea phase and the team performance should be guaranteed all along the process.

6.2.2 Development

The concern in the development phase lies in the validation of the potential of product concepts. Whether the product concepts are validated or not depends on their suitability to the market targeted. Hence, one should use market criteria to evaluate and select the product concepts with the best potential.

In the suitability of the products with the market, indicators should be able to display the market features, the assessment of the competition, the differentiation with competitors, the potential of the product within the market and the establishment of contacts who provide primary information. The following indicators were proposed: (i) Significant market size/growth/share, (ii) Easy access to market, (iii) Big strength of the need in the market, (iv) Fit of the product with market needs, (v) Establishment of a networking of contacts, (vi) Sufficient knowledge of the competition, (vii) Differentiation from competitors.

6.2.3 Commercialization

This phase has a major importance since it significantly contributes in building a convincing business case that will be presented to the investors. The commercialization stage delivers a plan for development which reunites the set of activities that must be undertaken in order to further develop the project until the commercialization. The indicators related to the development are: (i) Stable and explicit plan, (ii) Milestones are clear and realistic, (iii) Short time-to-market and (iv) Sufficient materials and human resources to perform the project.

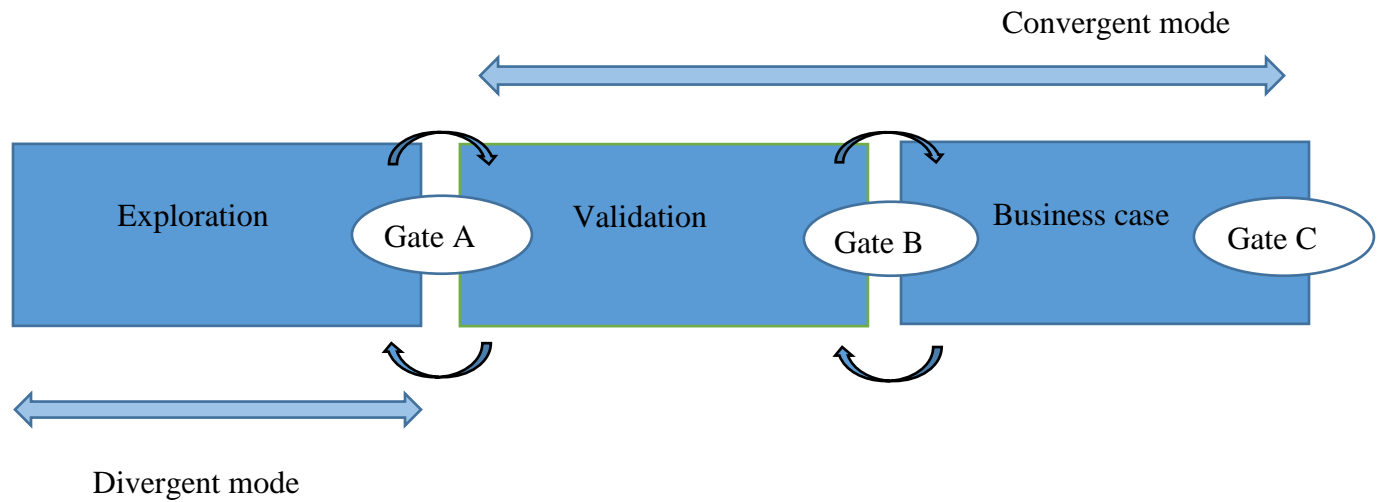
7. Discussions

7.1 Front end of innovation

The case study of Cohitec put in light three specific periods that typically constitute the front end of innovation. Based on former researches studied in the literature and the case study of Cohitec, a practical model of front end of innovation is proposed in this thesis. The new model of FEI presents three “moments” that will be named exploration, validation and business case.

The first period taking place in the very beginning of the front end is exploration and involves the exploration of opportunities and generation of ideas. This is the creative part of the process and belongs to the divergent mode which includes discovery and exploration activities (Palmer & Kaplan, 2007). In the validation, the stage deals with the development of product concepts and the validation of the findings. Product ideas generated are being evaluated and a minor part of them is selected for deeper researches and evaluations. In order to corroborate the product ideas, information specific about the market, the competition and the technology must be collected (Doll & Zhang, 2001). Finally, during the last period, team must elaborate a business case for the product idea with the best potential. The business case incorporates a business plan (including financial and business analysis), a product definition, a project justification and a plan for further development and commercialization (Khurana & Rosenthal, 1997). The two last stages described, conversely to the first one, are part of the convergent mode which uses the traditional business techniques with the aim of evaluating and refining the potential of the opportunities until the implementation (Palmer & Kaplan, 2007)

Figure 7: Practical model of FEI based on literature review and case study



Similarly to the Stage-gate model of Cooper (1988), the present model proposes management gates during which the project is being judged against a set of performance indicators. However, unlike the 1988' SG model it is not a linear process. The process is rather dynamic just as the new concept development model of Koen et al. (2001) meaning that activities are not performed in a sequential way and loop back can occur. The practical model of front end tries to enter in contact with market experts and customers for the validation of findings as soon as the exploration period has ended. Likewise the customer development process developed by Blank (2006), the purpose is to check whether there is a market and customers willing to pay for the product.

The sequence of these three periods in the innovation process were not pointed out in the models presented in the literature review i.e. the Stage gate model, the New Concept Development model and the Customer development model.

7.2 Indicators of performance

The case study revealed the importance of the time dimension when utilizing the indicators of performance. Specific indicators should be set at specific time during the innovation process in order to be pertinent.

When applying the indicators of performance developed in the literature review, it appears that all of them were found relevant in the case study with the exception of the strategic fit dimension.

The absence of strategic alignment criteria can be explained by the nature of the case study. Cohitec is an organization helping multiple independent entrepreneurial teams to develop a product and eventually a startup. Therefore, ventures do not exist yet and this may be the reason why strategic criteria were irrelevant within the case study.

The indicators applied to the case study follow the sequential aspect in the front end of innovation and are then classified whether they should intervene during the exploration, validation or business case stage. The competitive potential dimension was found pertinent in the exploration, while the effectiveness is more likely to take place in the business case stage as it refers mostly to the plan of development. Concerning the team dimension, it was split into team composition which is applicable at the very beginning of the innovation process i.e. exploration, while team dynamics is suggested to be evaluated through the whole innovation process.

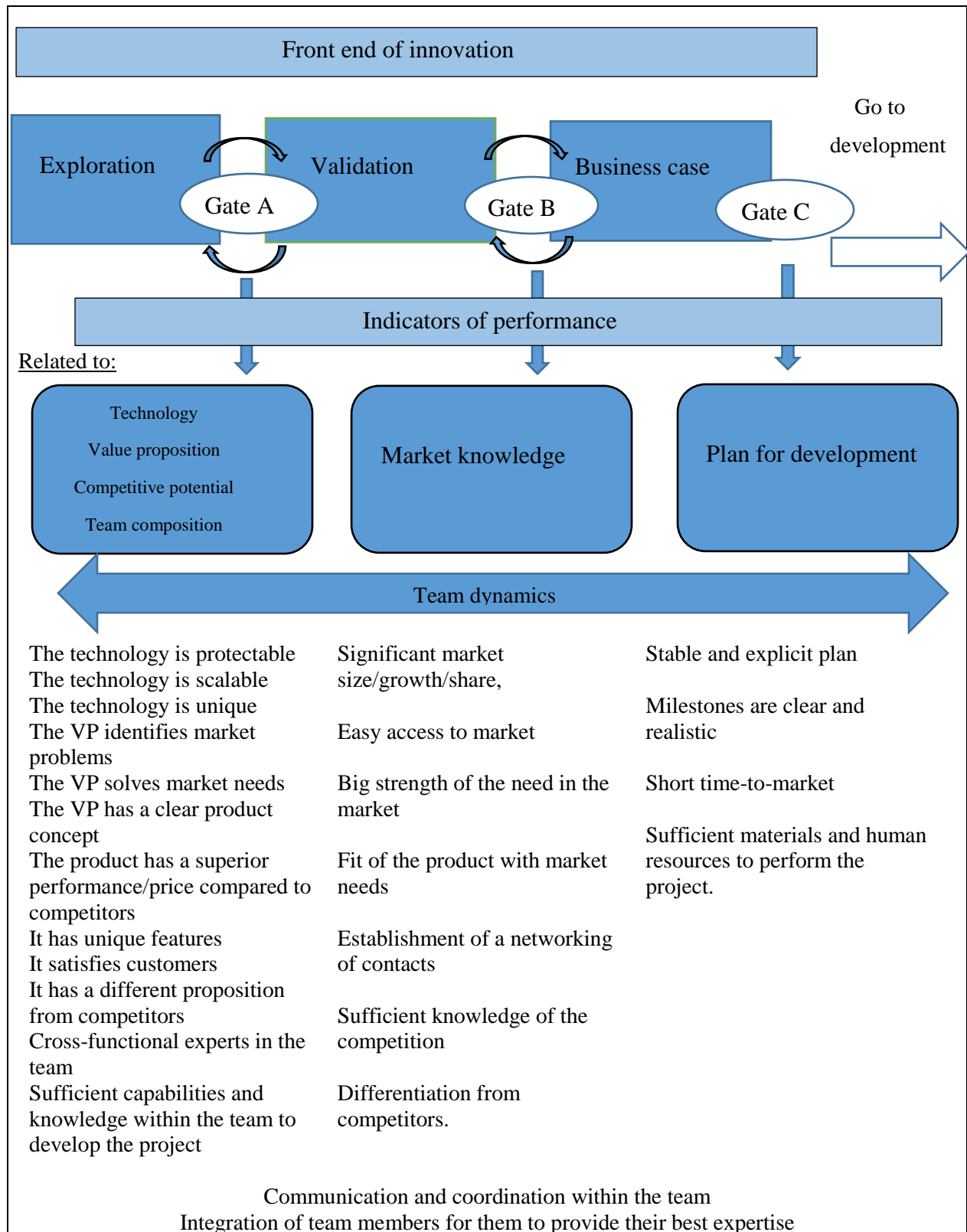
In addition to the indicators presented in the literature review, the case study enhanced the set of indicators by adding criteria related to the potential of the technology, the value proposition, the market knowledge and the plan for development.

The technology potential assessment can take place in the exploration period, at the very beginning of the innovation process. The literature review did not mention the importance of setting technology-related criteria whilst it was revealed to be necessary in the case study.

Market criteria was found relevant in the validation stage in order to ensure the suitability of the product within the targeted market. According to the literature review, the front end faces three types of uncertainties: technical, market and competition (Doll & Zhang, 2001). In the case study, technical uncertainty is being solved in the exploration stage whilst market and competition uncertainties are resolved in the validation stage through the information collected.

Finally, the case study highlights the need of setting indicators related to the plan for development. The literature review contains very few information about indicators for the development plan. However, it is just as important as the other indicators in order to bring a product with potential to the market in the best manner.

Figure 8: Summary of the findings of the case study



To sum up, the thesis has studied the indicators that monitor the performance all along the front end process. It confronted the model developed from the literature review with a practical model resulted from a case study of an accelerator.

Following Poskela & Martinsuo (2011)'s point of view, most criteria are subjective and do not rely on mathematical or statistical methods.

8. General conclusion

Multiple models of front end of innovation and especially three specific models were studied: linear, dynamic and entrepreneurial. Although they contended dissimilar frameworks, they also presented similarities. All of them agree to define the front end of innovation as a process reuniting all the activities until a business case is built and presented to the Management who takes the decision to move the project forward or to kill it.

The final outcome of the front end of innovation is the business case and it presents the product definition with all its specificities, the financial and business analysis and the plan of development. In the study of the indicators of performance, the literature review explicitly claimed that a performant front end is particularly crucial as the consequences of a not well-managed process can be significant.

The case study brought to light the importance of the timing in the front end of innovation when setting indicators of performance. Based on the observations made in the case study and the literature review, a practical model of front end of innovation was presented according to three specific moments named exploration, validation and business case.

The case study suggested to define indicators of performance by respecting the sequence of moments. In addition, the practical case of Cohitec enhanced the set of indicators developed in the

literature review by proposing extra indicators related to the technology, the value proposition of the product, the market knowledge and the plan of development.

However, the literature review did not take into account the timing during which indicators should intervene. The four dimensions of performance developed in the literature review were confirmed in the case study except for the strategic dimension which was found irrelevant in the case study. This was explained by the nature of the case study which trains independent entrepreneurial teams whose ventures do not exist yet and hence, strategic criteria are not found relevant.

8.1. Managerial implications

The first recommendation to make to the Cohitec Management is to define a set of indicators of performance that follows the front end structure in order to help their participants to monitor their project. For this purpose, a set of indicators was developed for the specific case of Cohitec- see appendix 1 was made available to the Management of Cohitec.

As Cohitec has not implemented any indicators in the past, it does not possess numerical data which would allow to provide quantitative indicators. Therefore, the second recommendation for Cohitec is to start tracking data related to the four technological fields in which it develops projects namely biotechnology, life sciences, industrial technologies and clean technologies in order to have a better knowledge of these industries.

The third recommendation concerns the assessment of the team performance. Cohitec Management seems aware of the importance of a quality team within a project but it does not give it evaluations. Therefore, it is strongly recommended to Cohitec to undertake team assessment either in the formal moments of assessments, either informally.

8.2. Limits and suggestions for further researches

The first limitation concerns the research method. This paper treats a single case study which makes difficult to generalize the findings. Therefore, the study of performance indicators should be extended to multiple case studies which would corroborate the findings or refute them. In addition, the multiple case studies should include established companies which would counteract the fact that specific criteria such as strategic ones were found irrelevant in an accelerator of pre startups.

Secondly, the research was limited to the study of indicators able to evaluate the current situation in the front end process. As a consequence, the set of indicators presented is not exhaustive and further researches should include the study of the omitted indicators of performance in order to enlarge the panel of indicators.

Thirdly, the scope of the thesis was restricted to the NPD innovation process. Therefore, the indicators were defined for the case of a product innovation and may not be applicable for all types of innovation (i.e. process, production, organizational forms, etc.).

Finally, it was decided to take on a qualitative research method which presents some limits. Data coming from qualitative researches are subject to individual opinions and personal perceptions which makes it common weaknesses of such a method. Future studies should consider to carry out quantitative research method in the area of performance indicators in the front end of innovation.

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10. Appendix

Appendix 1: set of indicators for Cohitec

	Strongly disagree	disagree	No opinion	agree	Strongly agree
“IDEATION” (EXPLORATION)					
1. The technology presents unique characteristics able to provide a competitive advantage					
2. The value proposition identifies a real problem and solves markets needs					
3. Each member of the team feels fully integrated in the team and is able to bring his/her full potential of expertise					
4. The technology is protected or currently in progress to be protected					
“DEVELOPMENT” (VALIDATION)					
1. The number of established contacts is able to provide the team enough primary information on the market					
2. The access to the market is relatively difficult (high barriers to entry, monopoly, etc.)					
3. The need of the market is significant					
4. The market size is sufficient and the market is growing					
5. The product features and benefits can answer market needs and provide a differentiation given the competitors					
“COMMERCIALIZATION” (BUSINESS CASE)					
1. The roadmap presents clear and realistic milestones					
2. The time-to-market is significant					
3. The investment required to market the products can without difficulty be funded by investors					
4. The team has the required skills to execute the project (technical, financial, marketing etc.)					